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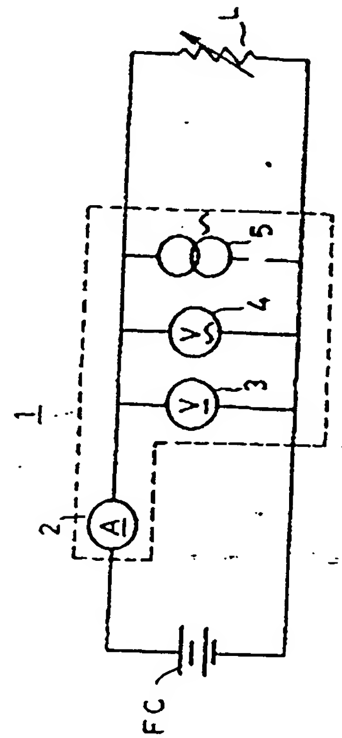
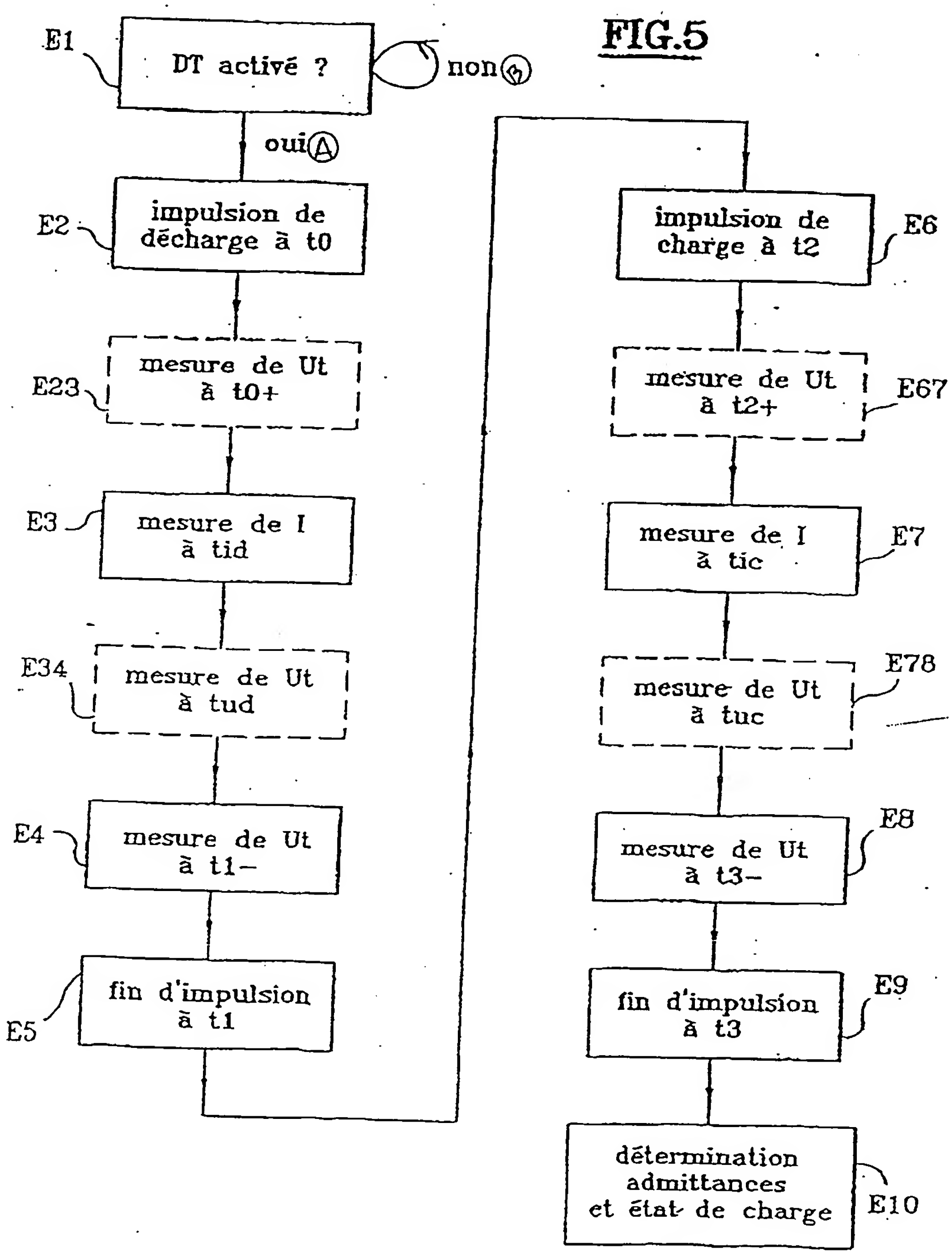
TITLE : TEMPERATURE CONTROL DEVICE OF FUEL CELL



ABSTRACT : PURPOSE: To detect the cell temperature from outside by measuring the internal impedance of a cell.

CONSTITUTION: An impedance measuring device 1 is connected between a fuel cell FC and a load L and is composed of a DC ammeter 2, a DC voltmeter 3, an AC voltmeter 4, and a constant-frequency, constant-current AC generator 5. The AC generator 5 feeds currents in parallel to the cell FC and the DC load L, and the AC voltage displayed on the AC voltmeter 4 is generated by the resultant impedance Zr of the internal impedance Z of the fuel cell FC and the load resistance R. Accordingly, individual detection signals from the impedance measuring device 1 are inputted to a control unit 6 to calculate the internal impedance Z of the cell. The value of this Z depends on the cell temperature, thereby this Z is used as an output signal to regulate a damper 7 and a blower 8 so as to control the feed air temperature and air quantity.

FIG.5



E1
DT activé ?
non
oui
E2
impulsion de décharge à t0
E23
mesure de Ut à t0+
E3
mesure de I à tid
E34
mesure de Ut à tud
E4
mesure de Ut à t1−
E5
fin d'impulsion à t1
E6
impulsion de charge à t2
E67
mesure de Ut à t2+
E7
mesure de I à tic
E78
mesure de Ut à tuc
E8
mesure de Ut à t3−
E9
fin d'impulsion à t3
E10
détermination admittances et état de charge

REPUBLIC OF FRANCE
NATIONAL INSTITUTE OF INDUSTRIAL PROPERTY
PATENT APPLICATION NO. 2 749 397 A1

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Filing Date:	June 4, 1996
Date of Public Access to Application:	December 5, 1997 Bulletin 97/49
List of Documents Cited in the Preliminary Search Report:	Refer to the end of this section.

PROCESS AND DEVICE FOR MEASURING THE CHARGE STATE OF A BATTERY

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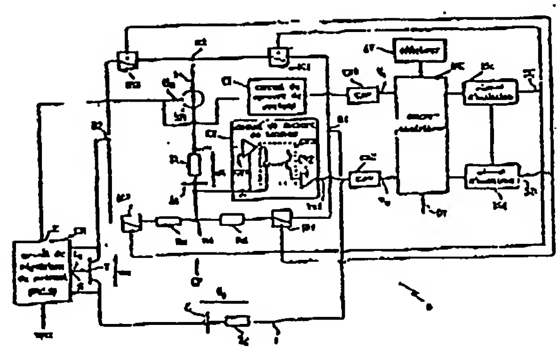
[Abstract]

The charge state of battery (At) is measured using the following steps when the charge state is high: a constant charging current pulse is applied to the battery, and voltage (Ut) across the terminals of the battery is measured for at least one predetermined time during the charging current pulse. The charge state of the battery is measured regardless of level using the following additional steps: a constant discharging current pulse is applied to the battery, and voltage (Ut) across the terminals of the battery is measured for at least one predetermined time during the discharging current pulse.

The charge state of a battery is evaluated even when the admittance characteristics of the latter are not injective.



Key: CI Current measurement circuit
AF Display device
MC Microcontroller
ISc, ISd Isolation circuit
CV Voltage measurement circuit
CR Current regulating circuit (Figure 3)

The present invention relates to a process for measurement of the charge state of a battery and to a device for implementation of the process. More specifically, the present invention relates to measurement of the charge state by applying pulsed stress to the battery.

The patent application FR-A-2 685 780 discloses a process for measurement of the charge state of an electrochemical generator which applies a constant voltage pulse to a battery in order to deliver a discharging current. Measurement of said discharging current is done immediately before the end of the pulse, which makes it possible to deduce the admittance of the battery and its charge state. However, this process can only be applied to cases where the internal admittance characteristic of the battery as a function of the charge state is injective, that is, a single charge state corresponds to a certain admittance. This only occurs for low charge state levels. For high charge states, it is not possible to evaluate the charge state of a battery by this process.

Furthermore, in practice, the curve characterizing the admittance of a battery as a function of its charge state is roughly linear for low charge states but bends for higher charge states. In Figure 1, curve Cdch is an example admittance characteristic as a function of the charge state of a nickel-cadmium battery obtained by applying a discharging current to the battery. The admittance, besides the non-bijective character of its characteristic, has low sensitivity to charge states higher than 60%, which means the evaluation of the charge state by means of a discharging current is not very precise.

The purpose of the present invention is to solve the aforementioned problems by providing a process and a device for measuring the charge state of a battery, which are more precise for high charge states and which can be used regardless of pulsed current.

For this purpose, a process for measuring the charge state of a battery is characterized by the fact that it includes the following successive steps:

- a constant charging current pulse is applied to said battery, and
- the voltage across the terminals of said battery is measured for at least one predetermined time during said charging current pulse.

The admittance characteristic as a function of the charge state obtained by applying a charging current to the battery, as shown by the curve Cch of Figure 1, is much more sensitive to high charge states, that is, greater than 60% in the case of a nickel-cadmium battery, than the admittance curve obtained with a discharging current.

The process according to the invention also relates to measuring the charge state of a battery for any pulsed current through the battery, regardless of the level of the charge state.

Thus, the process also includes the following successive steps:

- a constant discharging current pulse is applied to said battery, and
- the voltage across the terminals of said battery is measured for at least one predetermined time during said discharging current pulse.

The use of the two admittance characteristics, for a charging current and a discharging current, makes it possible to eliminate the ambiguity due to the non-bijective nature of these two curves.

In order to determine the response of the battery to the charging pulse, the step of measuring the voltage across the terminals of the battery during the charging pulse can be performed at a time immediately before the end of said charging pulse.

In a similar manner, the step of measuring the voltage across the terminals of the battery during the discharging pulse can be performed at a time immediately before the end of said discharging pulse.

In order to evaluate the admittance of the battery for a charging current, the process can include a step for measuring the current passing through the battery at a time close to the midpoint between the beginning and end of said charging pulse.

Likewise, the process can include a step for measuring the current passing through the battery at a time close to the midpoint between the beginning and end of said discharging pulse.

It is also desirable to be able to verify experimentally the theoretical voltage response of the battery for a constant charging current pulse. Steps can then be provided for measuring the voltage across the terminals of the battery at a time immediately after the beginning of said

charging pulse and at a time close to the midpoint between the beginning and end of said charging pulse.

In a comparable manner, the process can include steps for measuring the voltage across the terminals of the battery at a time immediately after the beginning of said discharging pulse and at a time close to the midpoint between the beginning and end of said discharging pulse.

A device for implementing the process according to the invention, for measuring the charge state of a battery to be tested by means of an auxiliary generator, is characterized by the fact that it includes

- a means for applying a charging current pulse to said battery from said auxiliary generator,
- a means for regulating the current passing through the battery to a constant value in order to assert a constant current on the battery during said charging pulse, and
- a means for measuring the voltage across the terminals of the battery for at least one predetermined time during said charging pulse.

The device can also include a means for applying a discharging current pulse to the battery from said auxiliary generator. The regulating means then asserts a constant current on the battery during said discharging pulse. The measuring means measures the voltage across the terminals of the battery for at least one predetermined time during said discharging pulse.

The auxiliary generator powers a bridge circuit formed by four lateral branches and a diagonal branch. The diagonal branch includes the battery. A first lateral branch includes a first switch. A second lateral branch includes a second switch and a discharging resistor. A third lateral branch includes a third switch and a charging resistor. A fourth lateral branch includes a fourth switch. The first and third lateral branches form said means for applying a charging current pulse to the battery from said auxiliary generator and they carry a current along with said diagonal branch only during a charging pulse. The second and fourth lateral branches form said means for applying a discharging current pulse to the battery from said auxiliary generator and they carry a current along with said diagonal branch only during a discharging pulse.

Typically, said means for regulating the current passing through the battery includes a Hall probe that is connected in series with the battery and that produces an output voltage depending on the current passing through the battery, a regulating circuit that receives the output voltage from the Hall probe, and a transistor that is connected in series with the auxiliary generator and whose base current is controlled by the regulating circuit in response to the variations of the current passing through the battery.

In order to regulate the current passing through the battery during the charging pulses and the discharging pulses, that is, independent of the current direction through the battery, the

regulating circuit can include at its input a rectifying circuit producing an output voltage equal to the absolute value of the output voltage of said Hall probe.

The regulating circuit can include an optoelectronic isolator, so as to isolate galvanically the means for measuring the voltage in the regulating circuit and the power circuit including the battery and the auxiliary generator.

Also for the purpose of isolation, the means for measuring the voltage across the terminals of the battery can include at least one optoelectronic isolator.

The device can also include a means, preferably galvanically isolated from the battery and from the auxiliary generator, for measuring the current passing through the battery.

Other characteristics and advantages of the present invention will appear more clearly upon reading the following description of several preferred embodiments of the invention in reference to the corresponding appended drawings in which:

- Figure 1 is a diagram showing two admittance curves of a nickel-cadmium battery as a function of the charge state (capacity/nominal capacity) of the latter, which are determined by respectively applying a charging current and a discharging current to the battery;

- Figure 2 is a block diagram of a device for measuring the charge state of a battery according to the invention;

- Figure 3 is a block diagram of a regulating circuit included in the measurement device of Figure 2;

- Figure 4A is a timing diagram for discharging and charging control signals delivered by a microcontroller included in the measurement device of Figure 2;

- Figure 4B is a timing diagram for the voltage response of the battery in Figure 2 to a constant discharging current pulse and to a constant charging current pulse; and

- Figure 5 is an algorithm of a process for measuring the charge state of a battery according to the present invention.

In reference to Figure 2, measurement device D for measuring the charge state of electrical battery At to be tested which has an internal impedance Zt includes, according to a first embodiment of the invention, bridge circuit CP formed by four lateral branches and one diagonal branch, and auxiliary electrical accumulator generator G. Generator G delivers a voltage Ug that is greater than the nominal voltage of battery At and has an internal impedance Zg. The voltage Ug is typically equal to 12 volts. The positive terminal of generator G is connected to first terminal B1 of bridge circuit CP. Second terminal B2 of bridge circuit CP is connected to the collector of NPN bipolar transistor T. The emitter of transistor T is connected to the negative terminal of auxiliary generator G.

First lateral branch B1-B3 of bridge circuit CP includes first switch IC1. Second lateral branch B1-B4 is made up of second switch ID1 and discharging resistor Rd connected in series.

Third lateral branch B2-B4 includes third switch IC2 and charging resistor Rc connected in series. Fourth lateral branch B2-B3 includes fourth switch ID2. Diagonal branch B3-B4 contains battery to be tested At and Hall probe SH connected in series. Switches IC1, ID1, IC2 and ID2 are MOS transistors.

Hall probe SH applies output voltage U_H to input E of current regulating circuit CR. Output S of circuit CR is directly applied to the base of transistor T.

Device D also includes microcontroller MC, whose role is to control switches IC1, ID1, IC2 and ID2 of bridge circuit CP and to sense numerical measurement data signals V_I and V_U which represent, respectively, the current flowing through battery At and the voltage at its terminals.

Device D generates constant charging and discharging current pulses in battery to be tested At.

In order to generate a charging pulse, microcontroller MC applies a charging control signal SC set to "1" to first and third switches IC1 and IC2 and discharging control signal SD set to "0" to second and fourth switches ID1 and ID2, so as to close switches IC1 and IC2 and to open switches ID1 and ID2. Current I flows from the positive terminal of auxiliary generator G, through switch IC1, Hall probe SH, battery At, charging resistor Rc, switch IC2 and into the collector-emitter junction of transistor T.

In order to generate a discharging pulse, microcontroller MC sets charging control signal SC to "0" and discharging control signal SD to "1", so as to open switches IC1 and IC2 and to close switches ID1 and ID2. Current I flows from the positive terminal of generator G, through switch ID1, discharging resistor Rd, battery At, Hall probe SH, switch ID2 and into the collector-emitter junction of transistor T.

Current I flowing through battery At is thus propagated in two opposite directions B3-B4 and B4-B3 in the diagonal branch of bridge circuit CP during the charging and discharging pulses, respectively, but in only one direction through transistor T, that is, from the collector to the emitter. Due to the presence of bridge circuit CP, a single current regulating circuit CR is activated for the two pulse types.

During a charging or discharging current pulse in battery At, the intensity of current I flowing through the battery is maintained constant by Hall probe SH, regulating circuit CR and transistor T. Hall probe SH transforms current I flowing in battery At into voltage U_H proportional to the intensity of current I. Voltage U_H is applied to input E of regulating circuit CR. Circuit CR provides regulating current I_R to the base of transistor T, which is dependent on voltage U_H and a positive reference voltage Vref. Regulating current I_R varies in order to regulate the collector current of transistor T and thus to regulate current I flowing through the battery at a constant value I0 proportional to reference voltage Vref.

Charging resistor Rc and discharging resistor Rd are chosen so that transistor T operates roughly following the middle of a segment limited by two intersecting points between the charging line of the transistor and the two axes of coordinates in the collector-current characteristic curve as a function of collector-emitter voltage Vce of the transistor. The transistor is typically polarized in the saturation zone of the aforementioned characteristic curve.

Current regulating circuit CR shown in Figure 3 is a negative feedback loop containing current sensor circuit 1, subtracter 2, error correction circuit 3, adder 4, optoelectronic isolator 5 and power amplifier 6. Current sensor circuit 1 essentially includes impedance corrector 10, rectifying circuit 11 and non-inverting amplifier 12.

Output voltage U_H of Hall probe SH is applied, at input E of circuit CR, to impedance corrector 10. Impedance corrector 10, consisting of an operational amplifier with simple feedback as shown in Figure 3, provides voltage |Umes| which is equal to voltage U_H. The input impedance of circuit 10 is very high so that very little current coming from Hall probe SH enters regulating circuit CR. Rectifying circuit 11 delivers a voltage |Umes| equal to the absolute value of input voltage Umes as output in order to make the sign of the latter voltage unnecessary. Rectifier circuit 11 thus provides amplifier 12 with a voltage which is always positive regardless of the direction of current I through battery At. Amplifier 12 amplifies voltage |Umes| into a positive voltage Vmes which is applied to a positive input of subtracter 2.

A negative input of subtracter 2 receives reference voltage Vref which is proportional to the desired current I0 to assert in battery during the charging and discharging pulses. Output signal (Vmes - Vref) of subtracter 2 is transmitted to error correction circuit 3. The latter is a conventional corrector of the proportional-integral type, also called PI corrector. The transfer function of the PI corrector is typically the sum of the transfer function for an inverting amplifier and the transfer function for an integrator.

The output of error correction circuit 3 is connected to adder 4 which delivers output voltage Vs equal to the sum of the output voltage of error correction circuit 3 and a predetermined positive polarization voltage Vpol. Voltage Vpol is set in such a way as to make transistor T conductive and to produce in battery At a current close to the desired current I0 to assert during the charging and discharging pulses.

The output of adder 4 is connected to optoelectronic isolator 5, and in particular to the anode of light-emitting diode D through resistor R1. The cathode of diode D is grounded. Light-emitting diode D, carrying the output current Is of adder 4, illuminates the base-emitter junction of NPN bipolar phototransistor Tph, thus creating a variable base current I_B through the base of the phototransistor which depends on current Is. The collector of phototransistor Tph is connected directly to the collector of transistor T. The emitter of transistor Tph is connected to the emitter and to the base of transistor T, respectively, through resistor R2 and through power

amplifier 6. Optoelectronic isolator 5 ensures galvanic isolation between adder 4 and power amplifier 6, and therefore between input E of the feedback loop and its output produced by transistor T.

Power amplifier 6 has the role of amplifying the collector current of phototransistor Tph and producing a sufficiently high regulating current I_R through the base of transistor T. Circuit 6 contains NPN bipolar transistor T1 whose base is connected to the emitter of phototransistor Tph, whose collector is connected to the collectors of phototransistor Tph and of transistor T, and whose emitter is connected through resistor R3 to the emitter of transistor T. As a variant, power amplifier 6 has several bipolar transistors that are cascade connected to one another in the same manner as transistor T1 with respect to phototransistor Tph.

Thus, during a charging current pulse in battery At controlled by microcontroller MC, current I through the battery tends to decrease during the pulse because of the charge on the latter. Subtracter 2 then produces a negative output voltage, which increases the output voltages of error corrector 3 and of adder 4 and current I_B through the base of phototransistor Tph, and thus increases current I such that it returns to the value I0.

Inversely, during a discharging current pulse in battery At, the current through the battery tends to increase during the pulse. Subtracter 2 then produces a positive output voltage, which decreases voltage Vs output by adder 4 and current I_B through the base of phototransistor Tph and thus decreases current I so that it returns to the value I0.

Device D for measuring the charge state of a battery also includes current measurement circuit CI and voltage measurement circuit CV, as shown in Figure 2. Analog voltage signals output by circuits CI and CV are provided to analog-digital converters CA1 and CA2, respectively, which transform these signals into digital measurement data signals V_I and V_U which are to be accepted and processed by microcontroller MC.

Voltage measurement circuit CV produces output voltage Vs1 equal to voltage Ut across the terminals of battery At, and galvanically isolates the battery from microcontroller MC. Circuit CV is made up, for example, of two amplifier-impedance correctors CV1 and CV2, of which the input of one is connected to battery At and the output of the other is connected to converter CA2, and of optoelectronic isolator CV3 which galvanically isolates the two amplifiers CV1 and CV2.

Current measurement circuit CI, according to a first variant, is identical to impedance corrector circuit 10 represented in Figure 3. According to a second variant, circuit CI is the same as impedance corrector 10 and voltage Umes is regenerated so that it is transmitted directly to analog-digital converter CA1, as indicated in the form of a dotted line output by impedance corrector 10 in Figure 3. Finally, according to a third variant, current measurement circuit CI is eliminated, and output voltage U_H of Hall probe SH is applied directly to converter CA1. According to the three aforementioned variants, current measurement circuit CI is isolated

galvanically by Hall probe SH from the power circuit including, in particular, battery At and auxiliary generator G.

In order to completely isolate the measurement sensing and control circuits including circuits CI, CV and MC of the power circuit including, in particular, battery At and auxiliary generator G, the control of MOS switches IC1, IC2, ID1 and ID2 by microcontroller MC is preferably galvanically isolated. For this purpose, device D includes first isolation circuit ISc that galvanically isolates the microcontroller from charging switches IC1 and IC2, and second isolation circuit ISd that galvanically isolates the microcontroller from discharging switches ID1 and ID2. In each of isolation circuits ISc and ISd, for example, a transformer isolates an amplification and pulse-shaping circuit connected to the microcontroller and two amplification circuits each connected to an MOS switch.

According to a second embodiment of the device for measuring the charge state of a battery, only charging pulses are considered. In this case, lateral branches B1-B4 and B2-B3 of bridge circuit CP are eliminated, as is one of charging switches IC1 and IC2. The charging current pulses are applied by auxiliary generator G using the remaining charging switch IC1 or IC2 controlled by signal SC output by microcontroller MC.

The process for measuring the charge state of a battery according to the invention is now given in detail in reference to Figures 4A, 4B and 5.

Figure 4A is a timing diagram for the logical charging control signals SC and the discharging control signals SD. Initially, these signals are in the "0" state. In response to an exterior test triggering pulse DT input to microcontroller MC, discharging control signal SD is set to "1" at a first time t0 in order to trigger a discharging pulse of constant current I = I0 in battery At. The discharging pulse ends at a second time t1 such that t1 - t0 = 480 ms. Signal SD is then returned to "0." At a third time t2 is chosen such that (t2 - t1) is roughly equal to (t1 - t0), charging control signal SC is set to "1" in such a way as to trigger a charging pulse constant current I in battery At. The charging pulse lasts until the fourth time t3 which is also 480 ms from the third time t2.

Thus, with each test triggering pulse DT, microcontroller MC starts a cycle which includes a discharging pulse followed by a charging pulse. Measurements of current I flowing through battery At and of voltage Ut across its terminals are sensed during the discharging and charging pulses. At the end of the cycle, admittance calculations are performed by the microcontroller in order to determine the charge state of the battery.

Figure 4B shows, as an example, a timing diagram of the variation of voltage ΔUt for voltage Ut across the terminals of the battery during the aforementioned discharging and charging pulses.

Figure 5 represents the algorithm used by microcontroller MC for measuring the charge state. In a first step E1, the microcontroller is in the standby state, waiting for test triggering pulse DT. When pulse DT activates the microcontroller, a discharging pulse is produced by setting discharging control signal SD to the "1" state in the next step E2 at time t0. In step E3, the measurement of current I flowing through battery At is sensed at a time tid between t0 and t1, that is, during the duration of the discharging pulse. Typically, tid is equal to the midpoint of t0 and t1. The measurement of current I is obtained by sensing digital signal V_I output by analog-digital converter CA1. In step E4, voltage Ut across the terminals of the battery is measured at a time t1- just before the end of the discharging pulse t1. Typically, t1- is equal to (t1 - 2 ms). The measurement of voltage Ut is obtained by sensing digital signal V_U output by analog-digital converter CA2. The discharging pulse is stopped by setting signal SD back to "0" in the next step E5 at time t1. A rest period is established from time t1 until time t2, during which signals SC and SD are "0" and no measurements are sensed.

In step E6, a charging pulse is produced by setting charging control signal SC to "1" at time t2. A measurement of the current is sensed in the next step E7 at time tic between t2 and t3. Preferably, tic is equal to the average of times t2 and t3. In step E8, voltage Ut across the terminals of the battery is measured at time t3- immediately before the end of the charging pulse t3. Time t3- is, for example, equal to (t3 - 2ms). In step E9, charging control signal SC is set back to "0," and the charging pulse is stopped at time t3. The cycle of sensing measurements is then complete.

In the course of a last step E10, admittance values of the battery are calculated for discharging and charging from the current and voltage values measured in steps E3, E4, E7 and E8. Associated with the admittance corresponding to the discharging, there are sometimes two charge state values in the curve Cdch describing the admittance during discharging as a function of the charge state represented in Figure 1. Likewise, there can be two distinct charge state values for the value of admittance during charging. The use of the admittance curves for both discharging and charging makes it possible to eliminate the ambiguity concerning the charge state and to evaluate this state precisely regardless of its value. The value of the charge state is displayed in step E10 by display device AF connected to microcontroller MC in device D.

According to a first variant of the algorithm shown in Figure 5, this algorithm also includes step E23 inserted between steps E2 and E3. In the course of step E23, the voltage across the terminals of the battery is measured at time t0+ immediately after the beginning of the discharging pulse t0, that is, equal to (t0 + 2 ms), for example. Step E34 is also provided between steps E3 and E4 for measuring the voltage across the terminals of the battery at time tud which is close to the midpoint of times t0 and t1, and which is typically equal to t0 + 300 ms. Additional steps E23 and E34 are not necessary for the establishment of the admittance and charge state

values, but are used to verify experimentally the behavior of the curve in terms of voltage response of the battery to a constant discharging current pulse, shown in Figure 4B.

According to a second variant, which can be combined with the first variant, the algorithm includes step E67 inserted between steps E6 and E7, and step E78 is implemented between steps E7 and E8. Step E67 consists of sensing a measurement of the voltage across the terminals of the battery at time t2+ which is immediately after time t2, and which is typically equal to (t2 + 2 ms). Another voltage value is measured in step E78 at time tuc which is close to the midpoint between t2 and t3, and which is equal to (t2 + 300 ms). Steps E67 and E78 have a similar role to that of steps E23 and E34, relating to the experimental verification of the behavior of the curve in terms of voltage response of the battery to a constant charging current pulse.

According to a third variant, corresponding to the second embodiment of the device described in the preceding, the algorithm used by the microcontroller only consists of steps E1 and E6 to E10. Only the charging current pulse is then considered, and step E10 determines the charge state of the battery preferably for high charge states, that is, states greater than 60% for a nickel-cadmium battery, as explained in the preamble of the description. Steps E67 and E78 can be used in the third variant in the same way as in the second variant.

Claims

1. Process for measuring the charge state of battery (At) characterized by the fact that it includes the following successive steps:

- (E6) a constant charging current pulse is applied to said battery, and

- (E8) voltage (Ut) across the terminals of said battery is measured for at least one predetermined time (t3-) during said charging current pulse.

2. Process according to Claim 1, wherein said step (E8) for measuring the voltage across the terminals of the battery during said charging pulse is performed at time (t3-) immediately before the end (t3) of said charging pulse.

3. Process according to Claim 1 or 2, which includes step (E7) for measuring current (I) flowing through the battery at time (tic) close to the midpoint between the beginning (t2) and the end (t3) of said charging pulse.

4. process according to any one of Claims 1 to 3, which includes steps (E67, E78) for measuring voltage (Ut) across the terminals of the battery at time (t2+) immediately following the beginning (t2) of said charging pulse and at time (tuc) close to the midpoint between the beginning (t2) and the end (t3) of said charging pulse.

5. Process according to any one of Claims 1 to 4, which also includes the following successive steps:

- (E2) a constant discharging current pulse is applied to said battery, and

- (E4) voltage (Ut) across the terminals of said battery is measured for at least one predetermined time (t1-) during said discharging current pulse.

6. Process according to Claim 5, wherein said step (E4) for measuring the voltage across the terminals of the battery during the discharging pulse is performed at time (t1-) immediately before the end (t1) of said discharging pulse.

7. Process according to Claim 5 or 6, which includes step (E3) for measuring current (I) flowing through the battery at time (tid) close to the midpoint between the beginning (t0) and the end (t1) of said discharging pulse.

8. Process according to any one of Claims 5 to 7, which includes steps (E23, E34) for measuring voltage (Ut) across the terminals of the battery at time (t0+) immediately after the beginning (t0) of said discharging pulse and at time (tud) close to the midpoint between the beginning (t0) and the end (t1) of said discharging pulse.

9. Device for implementing the process according to any one of Claims 1 to 8 for measuring the charge state of battery (At) to be tested by means of auxiliary generator (G), characterized by the fact that it includes

- means (IC1 and/or IC2) for applying a charging current pulse to said battery from said auxiliary generator (G),

- means (SH, CR, T) for regulating current (I) flowing through the battery at constant value (I0) in such a way as to assert a constant current on the battery during said charging pulse, and

- means (CV, CA2, MC) for measuring voltage (Ut) across the terminals of the battery for at least one predetermined time (t3-) during said charging pulse.

10. Device according to Claim 9, which also includes means (ID1, ID2) for applying a discharging current pulse to the battery from said auxiliary generator (G), said regulating means (SH, CR, T) for asserting constant current (I0) in the battery during said discharging pulse, and said measuring means (CV, CA2, MC) for measuring said voltage across the terminals of the battery for at least one predetermined time (t1-) during said discharging pulse.

11. Device according to Claim 10, in which said auxiliary generator (G) powers bridge circuit (CP) formed by four lateral branches and one diagonal branch, the diagonal branch includes said battery (At), first lateral branch (B1-B3) includes first switch (IC1), second lateral branch (B1-B4) includes second switch (ID1) and discharging resistor (Rd), third lateral branch (B2-B4) includes third switch (IC2) and charging resistor (Rc), and fourth lateral branch (B2-B3) includes fourth switch (ID2), said first and third lateral branches form said means for applying a charging current pulse to battery (At) from said auxiliary generator (G) and carry current (I) with said diagonal branch only during a charging pulse, said second and fourth lateral branches form

said means for applying a discharging current pulse to battery (At) from said auxiliary generator (G) and carry current (I) with said diagonal branch only during a discharging pulse.

12. Device according to any one of Claims 9 to 11, in which said means for regulating the current passing through the battery includes Hall probe (SH) connected in series with the battery and produces output voltage (U_H) which depends on said current flowing through the battery, regulating circuit (CR) receives said output voltage (U_H), and transistor (T) connected in series with said auxiliary generator (G) and its base current is controlled by said regulating circuit (CR) in response to the variations of said current flowing through the battery.

13. Device according to Claim 12, in which said regulating circuit (CR) includes, at the input, rectifying circuit (11) producing an output voltage equal to the absolute value of the output voltage of said Hall probe (SH).

14. Device according to Claim 12 or 13, in which said regulating circuit (CR) includes optoelectronic isolator (5).

15. Device according to any one of Claims 9 to 14, in which said means (CV) for measuring voltage (Ut) across the terminals of the battery includes at least one optoelectronic isolator (CV3).

16. Device according to any one of Claims 9 to 15, which includes means (SH, CI) that is preferably galvanically isolated from said battery (At) and from said auxiliary generator (G) for measuring said current (I) flowing through the battery.

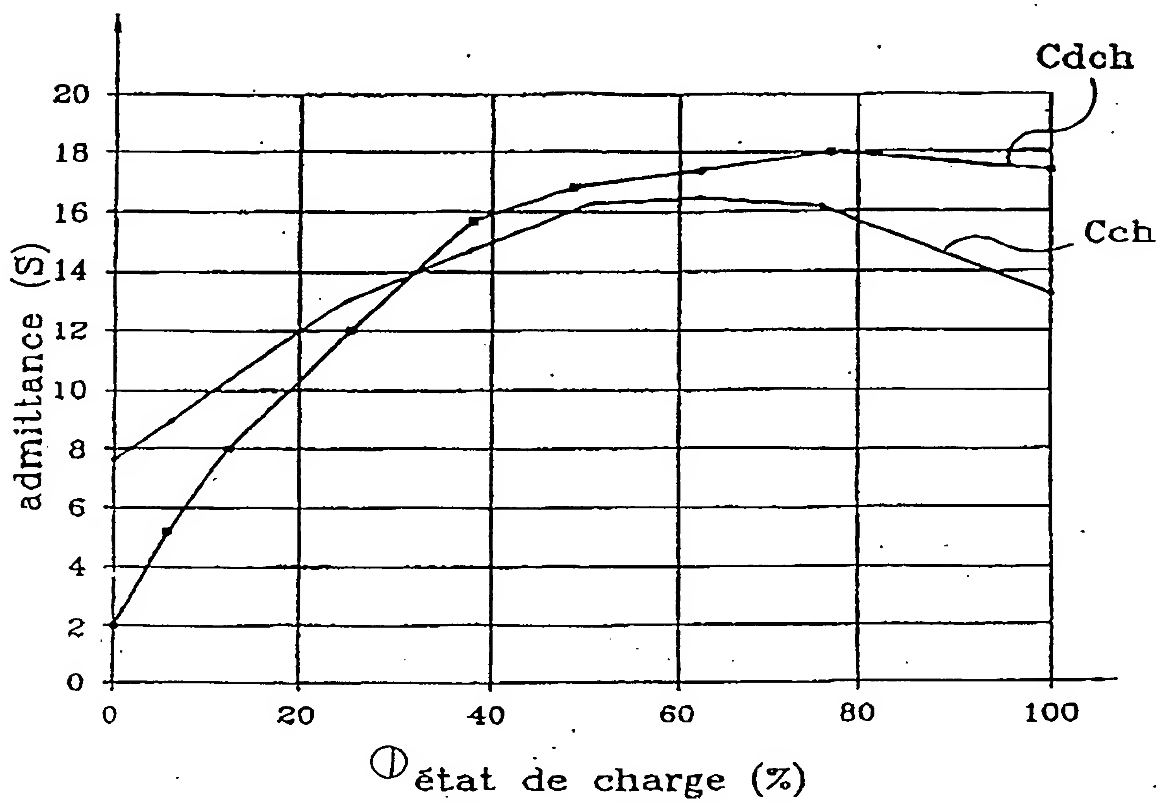
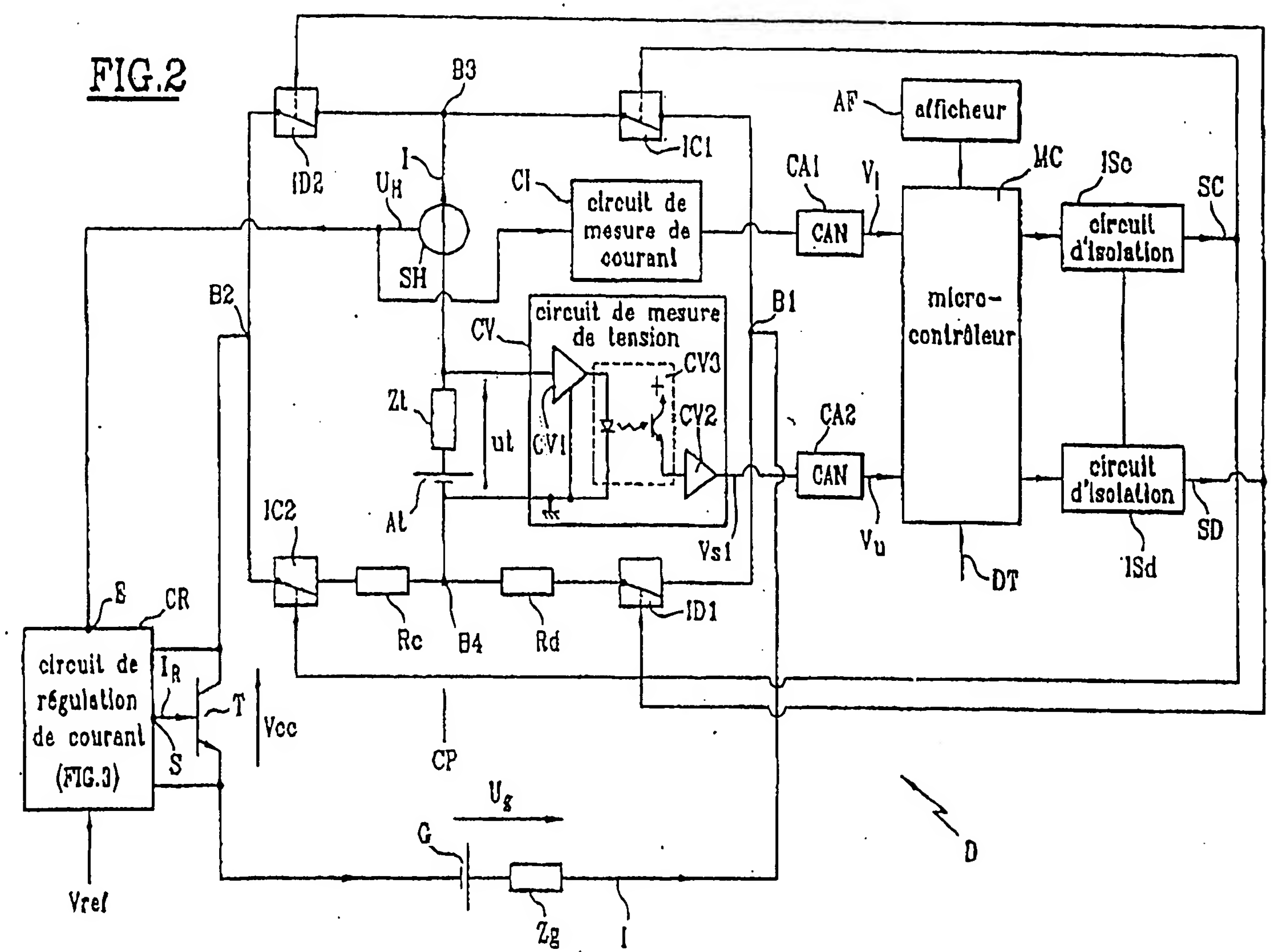


Figure 1

Key: 1 Charge state (%)

FIG.2



B3
ID2
IC1
I
U_H
CI
circuit de mesure de courant
CA1
V_I
CAN
AF
afficheur
MC
ISc
SC
circuit d'isolation
micro-contrôleur
SH
B2
B1
CV
circuit de mesure de tension
CV3
CV2
CV1
Zt
ut
At
CA2
CAN
circuit d'isolation
IC2
Vs1
V_u
DT
ISd
SD
ID1
Rc
B4
Rd
E
CR
circuit de régulation de courant (FIG.3)
I_R
T
Vcc
S
CP
U_g
G
Zg
I
Vref
D

[Key to previous page:]

CI	Current measurement circuit
AF	Display device
MC	Microcontroller
ISc, ISd	Isolation circuit
CV	Voltage measurement circuit
CR	Current regulating circuit (Figure 3)

[Key to previous page:]

CR	Current regulating circuit
1	Current sensor circuit
2	Subtracter
3	Error correction circuit
4	Adder
5	Optoelectronic isolator
6	Power amplifier
12	Amplifier

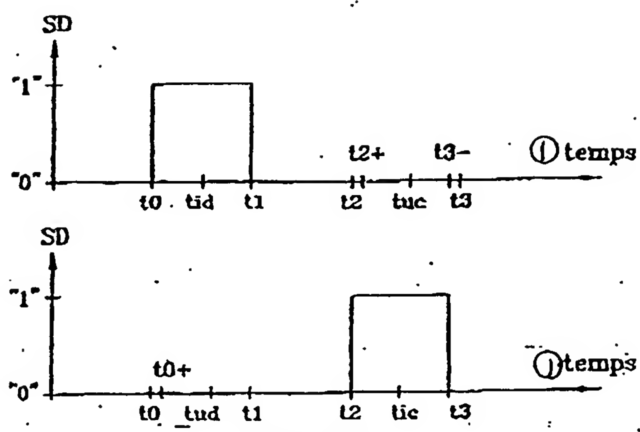


Figure 4A

Key: 1 Time

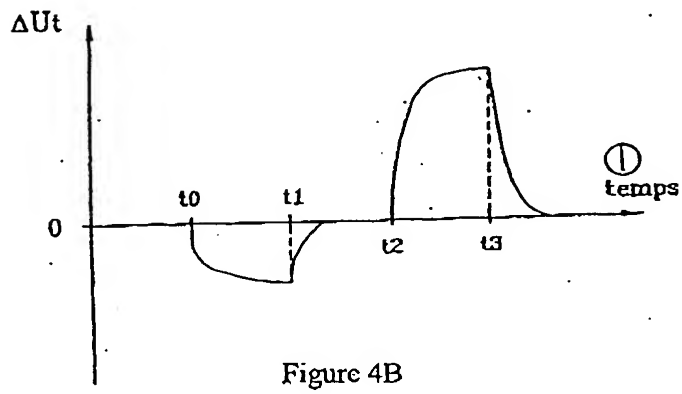


Figure 4B

Key: 1 Time

[Key to previous page:]

A	No
B	Yes
E1	DT activated?
E2	Discharging pulse at t0
E23	Measurement of Ut at t0+
E3	Measurement of I at tid
E34	Measurement of Ut at tud
E4	Measurement of Ut at t1-
E5	End of pulse at t1
E6	Charging pulse at t2
E67	Measurement of Ut at t2+
E7	Measurement of I at tic
E78	Measurement of Ut at tuc
E8	Measurement of Ut at t3-
E9	End of pulse at t3
E10	Determination of admittance and charge state values

FRENCH REPUBLIC
National Institute
of Industrial Property

Application Number
FA 529150
FR 9607132

PRELIMINARY SEARCH REPORT
established on the basis of the most recent claims filed before the start of the search

DOCUMENTS CONSIDERED TO BE RELEVANT		Claims concerned in the examined document	
Category	Citation of document with indication, where appropriate, of relevant passages		
X	EP 0 336 381 A (HABRA ELEKTRONIK GMBH) October 11, 1989 * abstract; figure * * column 5, line 29 – column 6, line 9 * * * column 7, line 5 – line 31 * * column 10, line 30 – line 34 * —	1-16	
Y D	EP 0 549 464 A (ALCATEL N.V.) June 30, 1993 * abstract; figures * * column 1, line 24 – line 43 * & FR 2 685 780 A —	1-16	
Y	GB 2 275 118 A (HEWLETT PACKARD CO) August 17, 1994 * page 1, line 14 – line 32; claim 10; figures 2,4 * * page 9, line 8 – page 10, line 27 * ---	1-16	TECHNICAL FIELDS SEARCHED (Int. Cl.6) G01R
A	WO 96 05508 A (CHAMPLIN KEITH S) February 22, 1996 * page 6, line 3 – line 26; figures 1-4 * —	1	
A	EP 0 689 061 A (ALSTHOM CGE ALCATEL) December 27, 1995 * abstract; figures 5, 6 * ---	1	

Date of completion of the search	Examiner
February 5, 1997	Fritz, S

CATEGORY OF CITED DOCUMENTS

X: Particularly relevant if taken alone.
Y: Particularly relevant if combined with another document of the same category.
A: Technological background.
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P: Intermediate document.
T: Theory or principle underlying the invention.
E: Earlier patent document, but published on, or after the filing date.
D: Document cited in the application.
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FIG.3

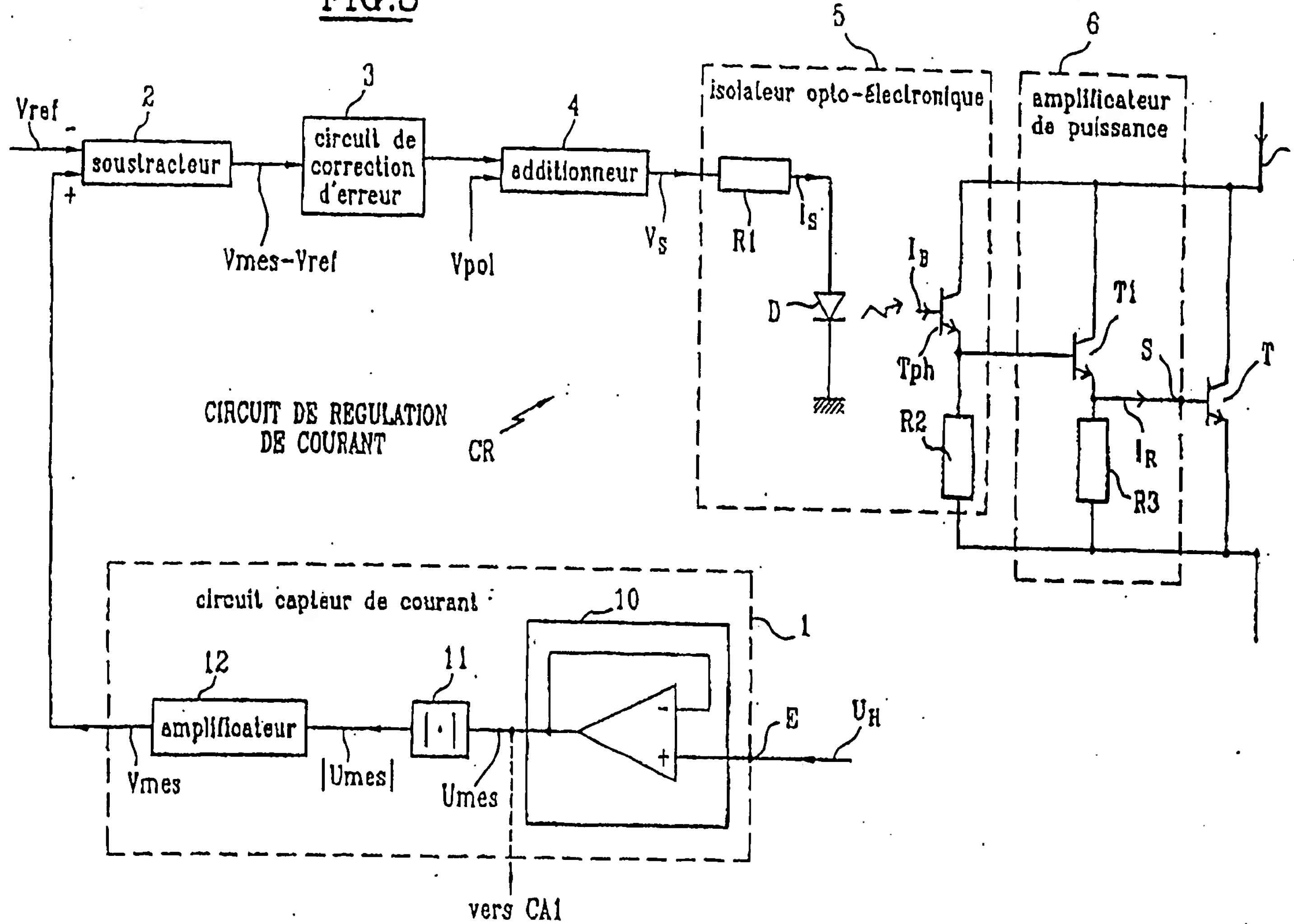
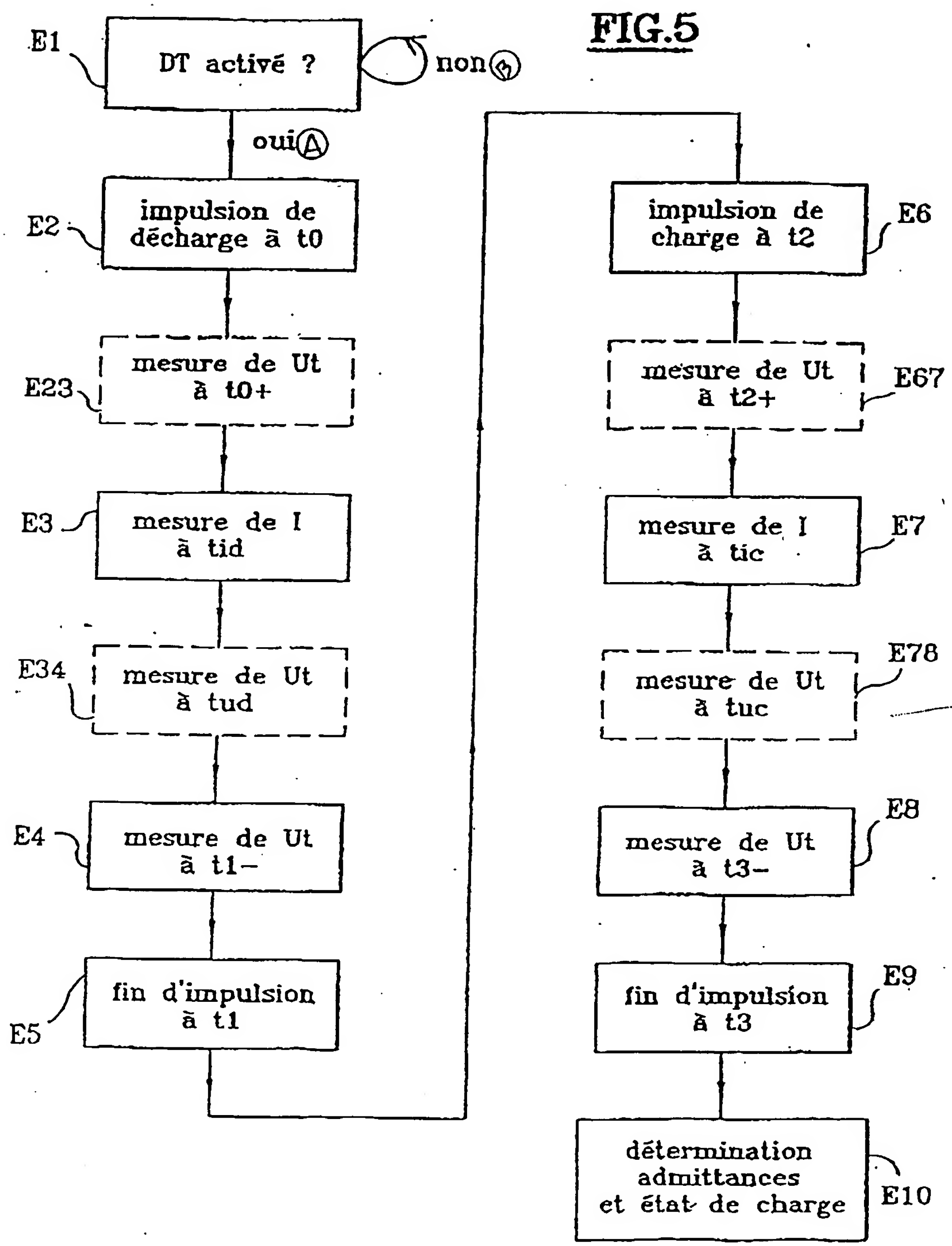

Vref
-
+
2
soustracteur
Vmes-Vref
3
circuit de correction d'erreur
4
additionneur
Vpol
Vs
5
isolateur opto-électronique
R1
Is
D
IB
Tph
R2
6
amplificateur de puissance
T1
S
IR
R3
T
I
CIRCUIT DE REGULATION DE COURANT
CR
circuit capteur de courant
1
10
12
amplificateur
11
|·|
Vmes
|Umes|
Umes
E
UH
vers CA1

FIG.5


E1
DT activé ?
non
oui
E2
impulsion de décharge à t0
E23
mesure de Ut à t0+
E3
mesure de I à tid
E34
mesure de Ut à tud
E4
mesure de Ut à t1−
E5
fin d'impulsion à t1
E6
impulsion de charge à t2
E67
mesure de Ut à t2+
E7
mesure de I à tic
E78
mesure de Ut à tuc
E8
mesure de Ut à t3−
E9
fin d'impulsion à t3
E10
détermination admittances et état de charge